

FINAL REPORT

Project 174/2022

Aims

The project aimed to investigate the neural correlates of conscious somatosensory perception and disentangle them from task relevance and report generation processes. Specifically, the objectives were:

1. To characterize Somatosensory Awareness Negativity (SAN or N140) in response to tactile stimulation and determine whether it reflects genuine awareness rather than decision/report processes.
2. To assess how stimulus intensity and task relevance modulate somatosensory awareness and electrophysiological markers, including the P3b component.
3. To construct and publicly release a high-density EEG (hd-EEG) dataset to support future research into sensory awareness versus task/report effects.

These aims align with the original application's focus on understanding tactile awareness mechanisms beyond subjective reporting and task engagement.

Distance from original proposal:

Although the core objectives of the project — namely, to dissociate neural markers of sensory awareness from report and task relevance — have been successfully addressed and consolidated with robust empirical support, some aspects originally envisioned have not yet been fully achieved. In particular, the systematic investigation of the contribution of the additional visual stimulus and its role in large-scale connectivity patterns, as assessed through source reconstruction analyses, connectivity modelling (DCM), comparisons between visual and visuo-tactile conditions, and attention manipulation contrasts, requires further refinement and more extensive data collection. While these components were explored and formed the basis of a recently defended Master's Thesis at the University of Parma, their comprehensive integration into a unified framework remains an ongoing objective. For this reason, this line of research is currently continuing and will be further developed in subsequent studies to ensure a more complete and conclusive assessment of these initially proposed goals.

Methods

Experimental Design

The project employed a two-pronged experimental strategy involving high-density EEG (see also Scientific Report 1 for further details):

1. No-Report Condition: Participants passively received tactile stimuli at individual sensory and motor thresholds without requiring explicit responses, designed to capture awareness-related neural activity uncontaminated by report demands.
2. Report Condition: Participants performed tasks with either task-relevant or task-irrelevant reporting instructions for visual or tactile stimuli, enabling comparison of neural responses driven by relevance and report production.

Participants

Although recordings were obtained from over 40 subjects, we decided to focus on and report data from 30 participants (right-handed, normal vision, no neurological disorders) to ensure the highest possible data quality. These healthy volunteers participated in both conditions.

Stimulation and Recording

Tactile stimulation was delivered via electrical stimulation of the median nerve at individually calibrated thresholds. EEG was recorded with 128 channels at 500 Hz.

Preprocessing and Analysis

Data were filtered, artifact-rejected, and epoched. Event-related potentials (ERPs), including N140/SAN and P3b components, were extracted, and scalp topographies analyzed.

Results and discussion

Somatosensory Awareness and ERP Components

The SAN/N140 component was robustly elicited across both report vs. no-report and task-relevant vs. task-irrelevant conditions, displaying frontal and contralateral scalp distributions consistent with tactile awareness processes. These findings support the interpretation of SAN/N140 as a reliable marker of conscious tactile perception that is largely independent of task demands or report generation. In contrast, the P3b component was predominantly modulated by task relevance and report production, indicating that it primarily reflects higher-order cognitive and attentional processes, rather than raw sensory awareness. This dissociation highlights the critical value of carefully separating experimental conditions to distinguish neural correlates of perceptual awareness from those associated with reporting or attentional control, in line with findings reported in Giorgi et al. (2025). In particular, the attentional contrasts captured in the comparisons between report vs. no-report trials and task-relevant vs. task-irrelevant conditions provide clear evidence for this dissociation.

Stimulus Intensity and Cross-Modal Modulation

ERP amplitudes scaled with stimulus intensity, confirming basic sensory processing effects. Cross-modal facilitation between visual and tactile inputs was observed, yet these effects remained at trend-level significance and did not reach conventional statistical thresholds. Consequently, planned source reconstruction and connectivity analyses (DCM) could not be meaningfully performed at this stage, as the absence of robust effects precludes reliable estimation of network interactions. While this limits our ability to fully characterize the underlying network dynamics, the observed trends suggest preliminary directions for future studies investigating cross-modal integration and attentional modulation.

Dataset Contribution and Integration with the Proposal

The high-density EEG dataset produced in this project includes both raw and preprocessed data, organized to facilitate reuse. This resource enhances reproducibility, enables independent validation, and provides a foundation for future algorithmic development. Importantly, the ERP results empirically validate the proposal's expectation that somatosensory awareness signals are dissociable from report- and task-related effects, showing a close match between planned aims and outcomes. The revised report will explicitly present all relevant ERP and imaging results to contextualize the absence of significant visual or visuo-tactile modulations. Additionally, these analyses are being further explored as part of the Master's thesis of one of the students involved

in the project (currently under embargo). Although this work extends beyond the formal timeline of the funded project, it continues due to the high scientific relevance of the underlying questions, particularly regarding attention, cross-modal interactions, and the neural mechanisms of conscious perception.

Conclusions and Implications

- SAN/N140 serves as a robust and task-independent marker of conscious tactile perception.
- P3b predominantly indexes task relevance and report production, rather than intrinsic awareness.
- Visual and visuo-tactile modulations were observed only at trend-level, explaining why source reconstruction and connectivity analyses were not feasible.
- A high-density EEG dataset has been successfully generated and publicly released, providing a valuable resource for ongoing research in somatosensory and attentional processes.
- Overall, the outcomes confirm key predictions of the proposal, while transparently reporting where planned analyses could not be performed due to lack of interpretable effects. They also highlight ongoing work extending beyond the formal project timeline, with potential to further elucidate the mechanisms of attention, cross-modal facilitation, and sensorimotor awareness.

Scientific Impact

These findings advance the understanding of conscious tactile perception by demonstrating a clear dissociation between perceptual awareness and report- or task-dependent processes, providing a strong empirical foundation for future investigations into sensorimotor integration, attention, and multisensory processing. Furthermore, the public release of a high-density EEG dataset ensures that these results are accessible for replication, methodological testing, and algorithmic development, amplifying the broader impact of the project.

Recommendations

1. Clinical and Translational Research: Use the dataset to explore somatosensory awareness in clinical populations with awareness deficits.
2. Algorithm Development: Leverage the high-density EEG data for machine learning and neural decoding.
3. Extended Analyses: Integrate source and connectivity results with structural imaging to refine models of awareness networks.
4. Future Experiments: Employ similar no-report paradigms in other sensory modalities to test the generality of isolation between awareness and reporting processes.